INSTITUTE OF AGRICULTURAL ENGINEERING
Tropics and Subtropics Group

Optical detection of two-spotted spider mite infestation in cucumber using vegetation indices

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Problem and Objective

- Two-spotted spider mite (*Tetranychus urticae* Koch) feeds on the under-surface of cucumber leaves by piercing cells with chloroplast.
- As a result, yellowing of leaves occurs, chlorophyll content and assimilation surface are reduced, which could ultimately lead to yield loss and plant death.
- This study aimed at optical detection of spider mite infestation on cucumber. Therefore, vegetation indices (VIs) of healthy and infested leaves were compared.

Material and Methods

- Four VIs were identified based on literature review (Table 1).
- VIs were calculated using reflectance data obtained from hyperspectral imaging with Cubert camera (Figure 1).
- Ten infested (50 spider mites per plant) and ten healthy leaves were compared. At the time of infestation plants were four weeks old.
- Two weeks after infestation snapshots were taken. For image acquisition (30 measuring points per leaf) (Figure 2), leaves were plucked and placed on a camera platform (objective distance 43 cm, controlled light conditions with a halogen bulb).
- Performance of VIs was analyzed with statistical software R (R version 4.0.3, R Core Team 2020).

Results and Discussion

- Leaf spectral signatures proved minor absorption of green light when compared to blue and red, as well as a sudden increase at the red edge border (690-740 nm) (Figure 2).

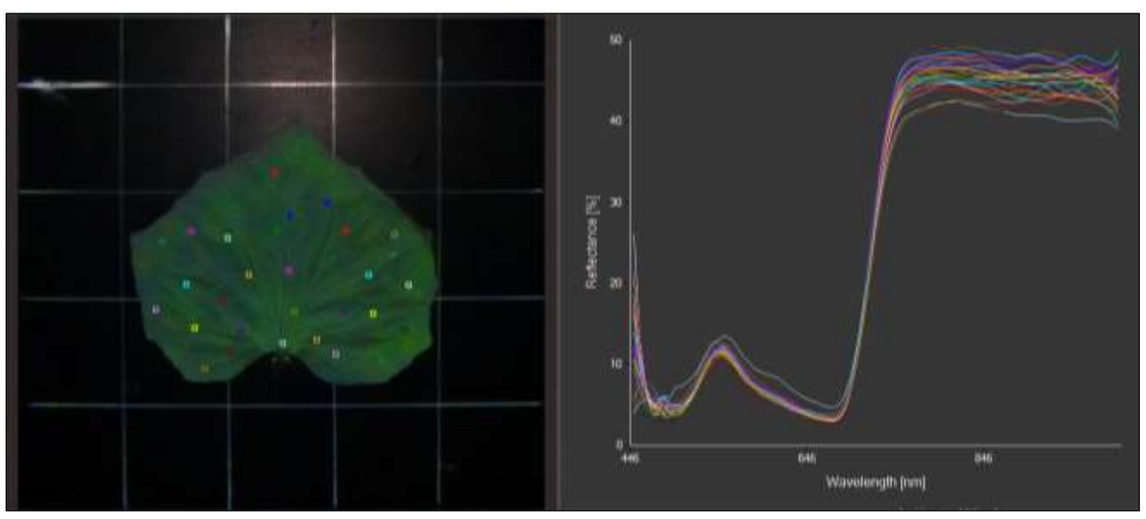

Figure 2: Thirty random measurements of a healthy cucumber leaf (left) and respective spectral signatures (wavelength depenent curve of relative reflectance values) (right).

- Three VIs showed statistically significant differences within the compared data (Table 1).

Figure 1: Cubert FireflEYE 185.

Camera specifications:

- 3D hyperspectral snapshot imager (x, y, λ),
- wavelength range 450-950 nm,
- 125 spectral bands,
- sampling interval 4 nm,
- spatial resolution 50 x 50 pixel,
- spatial resolution (2nd sensor) 1000 x 1000 pixel,
- sensor size 1 megapixel,
- weight 490 g.

Table 1: Comparison of selected indices after ANOVA was performed (different letters indicate the ability of each index to significantly separate between healthy and infested leaves, whereas same letters stand for not significant differences, $p < 0.05$).

Name	Formula	Healthy	Infected
Green Normalized Difference Vegetation Index (GNDVI)	$(\rho_{NIR}-\rho_G)/(\rho_{NIR}+\rho_G)$	a	b
Near Infrared Red Edge Normalized Difference Vegetation Index (NRENDVI)	$(\rho_{NIR}-\rho_{RE})/(\rho_{NIR}+\rho_{RE})$	a	b
Red Edge Inflection Point (REIP)	$700+40(((\rho_{670}+\rho_{780})/2-\rho_{700})/(\rho_{740}-\rho_{700})$	a	a
Triangular Greenness Index (TGI)	$-0,5((R-B)/(\rho_R-\rho_G)-(R-G)/(\rho_R-\rho_G))$	a	b

ρ = relative reflectance value of the subscripted wavelength
B (blue) = 490 nm, G (green) = 560 nm, R (red) = 666 nm, RE (red-edge) = 715 nm, NIR (near-infrared) = 790 nm

Conclusions and Outlook

- Three out of four investigated VIs are able to distinguish between healthy and infested leaves.
- Possible cucumber specific VIs will be investigated.
- Early visible infestation will be addressed in further research.
- For practical applications, automated spider mite detection devices need to be developed.

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